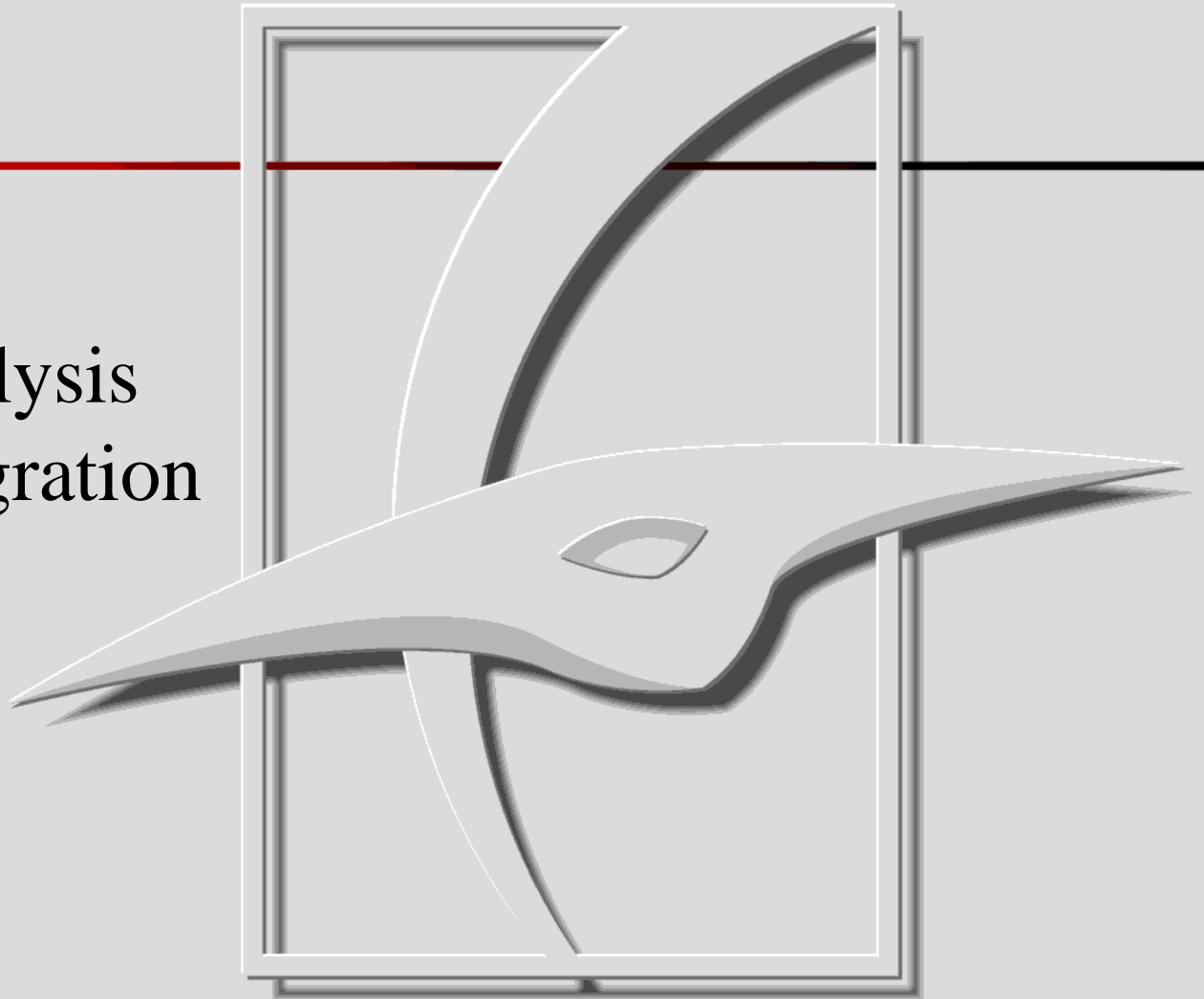


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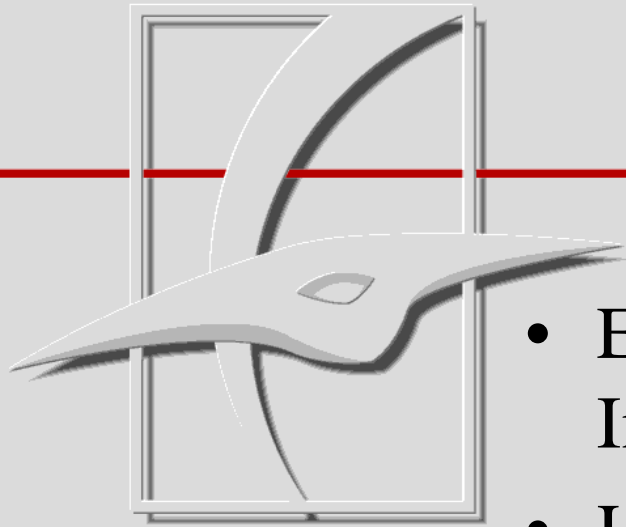
# Enterprise Analysis Information Integration with STEP



Keith Huntten, P.E.  
Lockheed Martin Tactical Aircraft Systems

# Overview

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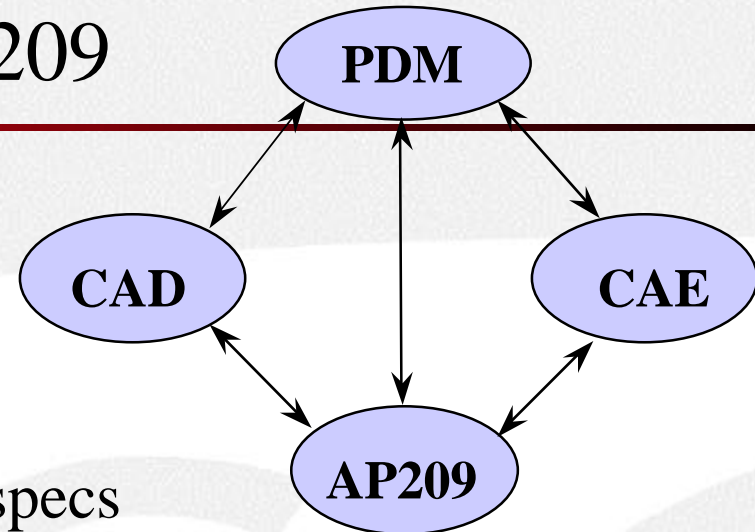


- Enterprise Analysis Information Integration with AP209
- History of AP209 and Part 104 Development
- Review of AP209 Content, Status and Implementations
- Integrating the Design/Analysis/Manufacturing Process with STEP AP209 Technology
- AP209 Status

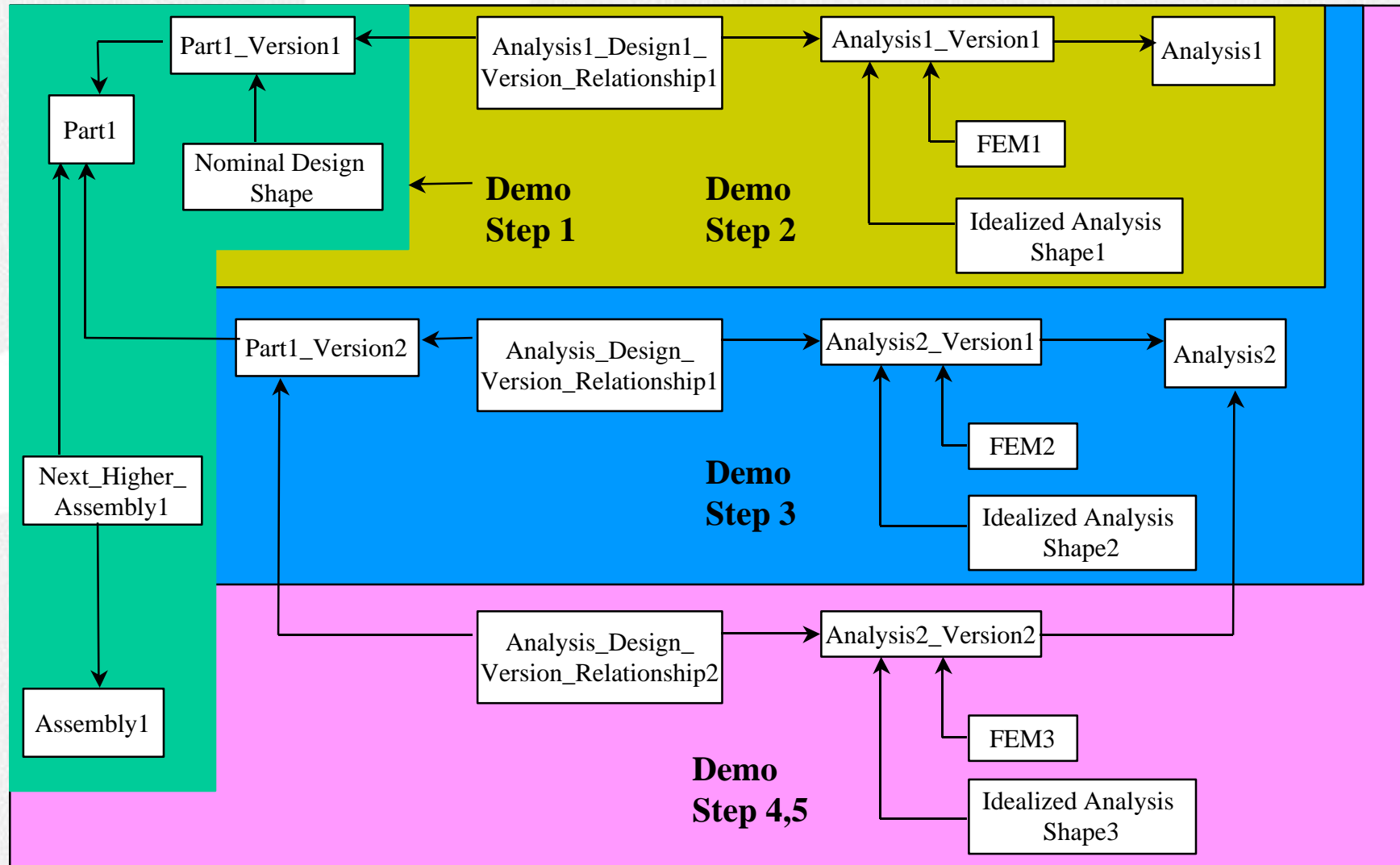
# Enterprise Analysis Information Integration with AP209

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- Enables sharing of PDM controlled composite and metallic design and analysis information, material properties/specs
- Enables automated, electronic feedback of product shape, performance, and property analyses to CAD with respect to PDM product structure and versioning
- Platform to extend engineering analysis STEP coverage into other analysis disciplines
- Provides a long term, potentially growing, repository crucial to many industries and vendors
  - Neutral format for PDM/CAD/CAE



# AP209 NOT Just FEA - It Enables Versioned Design/Analysis Information Sharing and Aggregation Within a Product Structure



# History of AP209 and Part 104 Development

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- AP209 development initially funded by USAF Wright Labs Materials Technology Division
  - Team of SCRA, Northrop-Grumman, LMTAS, and Boeing developed standard through CD status
  - ISO Engineering Analysis committee (TC184/SC4/WG3/T9), PDES, Inc. and LMTAS then processed CD ballot issues to create DIS version
- Part 104 initially developed within STEP EA committee
  - PDES, Inc. helped with DIS figures, LMTAS did ballot comment editing
- Both standards have been developed and reviewed by a large body of companies and standards organizations



# AP209: Composite & Metallic Structural Analysis & Related Design

## Analysis Discipline Product Definitions

- Finite Element Analysis
  - Model (Nodes, Elements, Properties,...)
  - Controls (Loads, Boundary Constraints,...)
  - Results (Displacements, Stresses,...)
- Analysis Report

## Design Discipline Product Definition

- Shape Representations
- Assemblies

## Configuration Control, Approvals

- Part, product definitions
- Finite element analysis model, controls, and results

## Information Shared Between Analysis & Design

- 3D Shape Representations
- Composite Constituents
- Material Specifications & Properties
- Part Definitions

## Composite Constituents

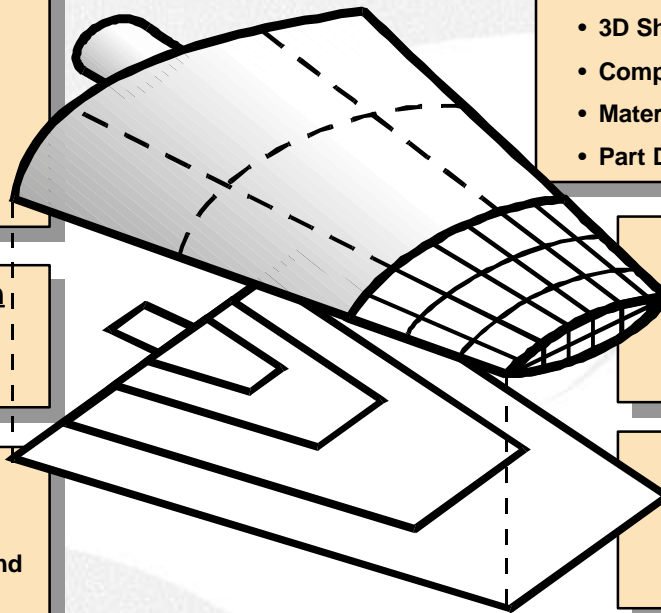
- Ply Boundaries, Surfaces
- Laminate Stacking Tables
- Reinforcement Orientation

## Material Specifications & Properties

- Composites
- Homogeneous (metallics)

## 3D Shape Representation

- AP202/203 Commonality Plus Composite Specific 3D Shapes
  - Advanced B-Representation
  - Faceted B-Representation
  - Manifold Surfaces With Topology
  - Wireframe & Surface without Topology
  - Wireframe Geometry with Topology
  - Composite Constituent Shape Representation



# Part 104: Finite Element Analysis

## Finite Element Model

- Administrative information
- Link to product definition

## Nodes

- Location
- Output coordinate system
- Geometric associativity

## Elements

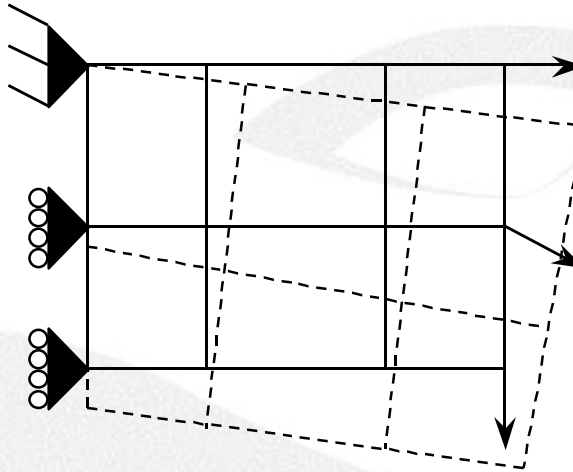
- Curve, surface, volume, explicit
- Comprehensive surface and curve properties
- Optional matrix integration specification
- Parametric locations (shared with results)
- Geometric associativity
  - Edge, face, volume

## Part 104 Scope

- Linear static, modes and frequency analyses
- Designed to accommodate nonlinear analyses
  - 95% + of required information already covered in Part 104

## Analysis Controls

- Administrative information
- Must apply to a model
- General structure allows load cases to be:
  - Specified
  - From a previously calculated case
  - Linear combinations



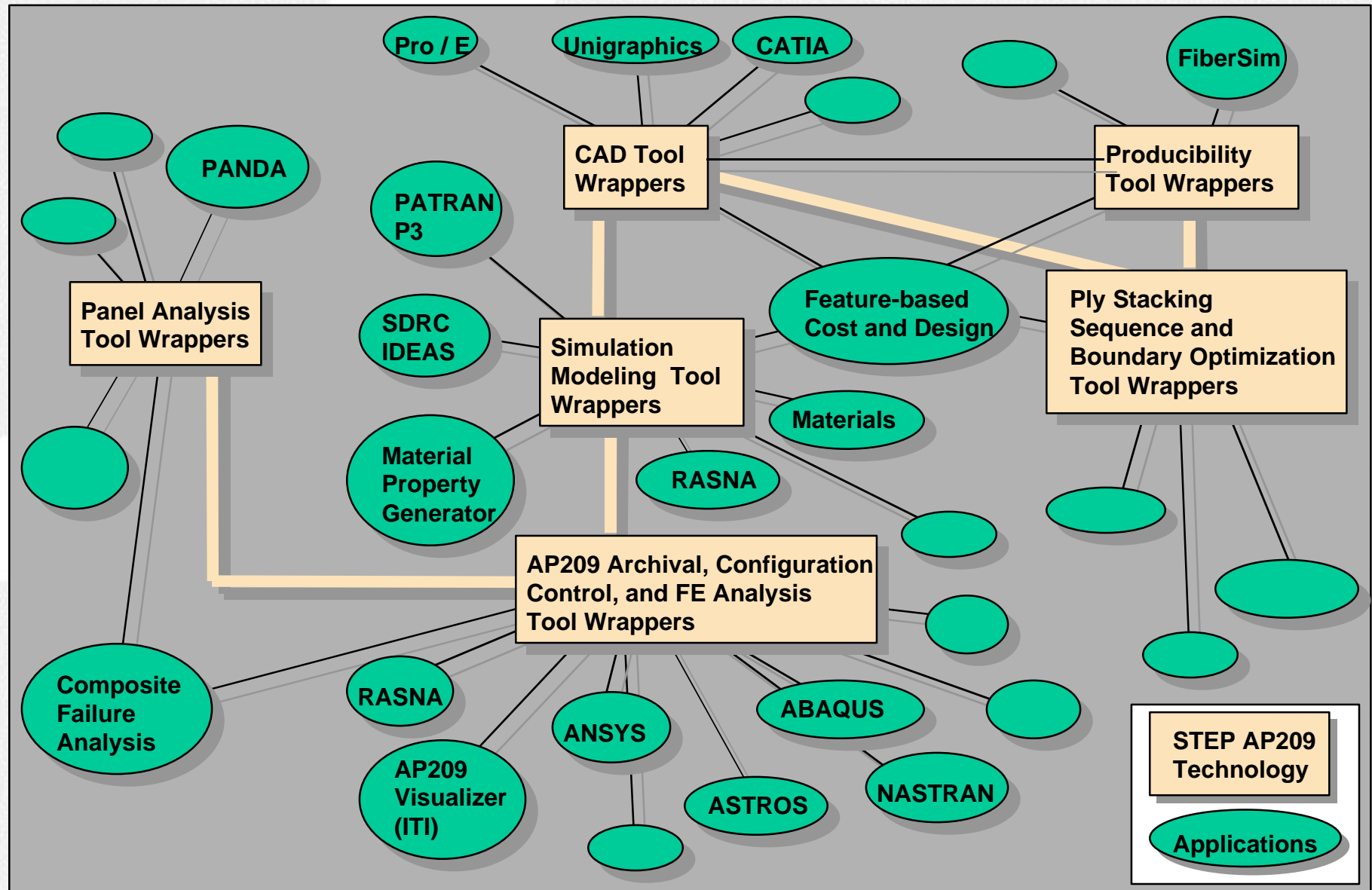
## Loads, Constraints, and Analysis Output

- Administrative information
- Element and nodal field output specified by general scalars/vector/tensors and corresponding variables
- Analysis output and loads share common form
- Single and multi node constraints

## Materials

- Specified by general fourth order tensors
- General iso/anisotropy continuum properties
- Specialized shell properties
- Links to material specifications

# Integrating the Design/Analysis/Manufacturing Process with STEP AP209 Technology





# Review of AP209 Implementations

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- Completed and based upon AP209 Committee Draft (CD)
- PDES, Inc. Design-To-Analysis Phase 1 and Army Tank Command (1994), PAS-C Final Demonstration (1996)
  - Ford, Boeing, Lockheed Martin, NG-Vought, ITI, MSC
  - Auto And Composite Tank Structures, Aircraft Composite Structures
  - CAD-To-CAE-To-CAE
  - COTS CAD/CAE (ARIES, PATRAN, NASTRAN, ITI/STRESSLAB, Unigraphics)
  - Linear Static FEA
  - Videos Generated, PDES, Inc. TAC Demos
- DARPA MADE/IPDE Program Phase 1 (1996)
  - Boeing, ASU, MSC
  - Aircraft Structures
  - CAD-To-CAE(CFD)-To-CAE(Structures)-To-CAE(CFD)
  - COTS CAD/CAE (CATIA, PATRAN, NASTRAN)
  - Boeing Proprietary CFD (AGPS/A502)
  - Iterative 1st Order CFD And Linear Static FEA
  - In-House Boeing Demo, PDES, Inc. Offsite Presentation

# Review of AP209 Implementations (Cont.)

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- Based upon AP209 Draft International Standard (DIS) - Lockheed, Electric Boat, MSC (1998)
- Electric Boat Design-To-Analysis Process
  - Ship Structures
  - CAD-To-CAE-To-CAE-To-CAD
  - COTS CAD/CAE (PRO/E, PATRAN, NASTRAN)
  - Electric Boat Proprietary (COMMANDS, FESOL)
  - Multiple Idealized Geometric Shapes And FEM/FEA Models
  - Linear Static And Dynamic FEA
  - PDES, Inc. TAC Demo (November 1998)

# AP209 Status

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- The Draft International Standard (DIS) version of AP 209 Composite and Metallic Structural Analysis and Related Design was approved unanimously December 20, 1999
  - International consensus is wide and there were no technical issues expected
    - 14 Yes (2 with comments), 3 abstain, 0 No
  - Part 104 - Finite Element Analysis - similarly has widespread international consensus and was approved on the same date with the same votes
- Extensive piloting has debugged and proven the AP209/Part 104 schema to be correct and capable